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14. ABSTRACT This grant provided a \$43,832 supplement to the DARPA award, "Design and Fabrication of Integration Biological Systems," to support the design, fabrication, and use of polydimethylsiloxane (PDMS) microfluidic chips and manifold control equipment.					
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a. REPORT UU	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER 617-899-5420

## Report Title

Design and Fabrication of Integration Biological Systems

### ABSTRACT

This grant provided a \$43,832 supplement to the DARPA award, "Design and Fabrication of Integration Biological Systems," to support the design, fabrication, and use of polydimethylsiloxane (PDMS) microfluidic chips and manifold control equipment.

**List of papers submitted or published that acknowledge ARO support during this reporting period. List the papers, including journal references, in the following categories:**

#### (a) Papers published in peer-reviewed journals (N/A for none)

A single manuscript describing the research conducted with the support of this manuscript is being prepared, and will be submitted for publication in 2008. The manuscript describes the successful design and operation of a cell sorting chamber within a 16nl working volume PDMS chemostat. An online lab notebook provides current information (<http://openwetware.org/wiki/SortoStat>).

Number of Papers published in peer-reviewed journals: 0.00

#### (b) Papers published in non-peer-reviewed journals or in conference proceedings (N/A for none)

Number of Papers published in non peer-reviewed journals: 0.00

#### (c) Presentations

Number of Presentations: 0.00

#### Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

#### Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

#### (d) Manuscripts

Number of Manuscripts: 0.00

Number of Inventions:

#### Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
Jason Kelly	0.00
Ty Thomson	
<b>FTE Equivalent:</b>	<b>0.00</b>
<b>Total Number:</b>	<b>2</b>

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### Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
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FTE Equivalent:

Total Number:

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### Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	National Academy Member
Drew Endy	0.00	No
FTE Equivalent:	0.00	
Total Number:	1	

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### Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
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FTE Equivalent:

Total Number:

### Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: .....	0.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:.....	0.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....	0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):.....	0.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering: .....	0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense .....	0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: .....	0.00

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### Names of Personnel receiving masters degrees

<u>NAME</u>
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Total Number:

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### Names of personnel receiving PHDs

<u>NAME</u>
Jason Kelly (2008, expected)
Ty Thomson (2008, expected)
Total Number:

2

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### Names of other research staff

NAME

PERCENT SUPPORTED

**FTE Equivalent:**

**Total Number:**

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**Sub Contractors (DD882)**

**Inventions (DD882)**

\*\*\* Final Report \*\*\*

Project: Supplement to "Design & Fabrication of Integrated Biological Systems"

Sponsoring Agency: US Army Research Office

Performing Institution: MIT Department of Biological Engineering

PI: Drew Endy

Report:

This supplement provided \$43,832 to be used for the design, construction, and operation of polydimethylsiloxane (PDMS) microfluidic devices. The total amount spent by the supplement expiration date of 8/31/2007 was \$34,361, with \$9,471 of unspent funds returned.

The purpose of the supplement was to explore and, if possible, demonstrate that we could establish PDMS microfluidic technology in my laboratory without also needing to become experts at manufacturing PDMS microfluidic chips. In other words, we hoped to demonstrate that it would be possible to decouple the design of custom PDMS microfluidic chips from the manufacture of the chips themselves (the decoupling of design and manufacturing is an important step in the scaling of a technology; for example, our work was informed and inspired by the earlier work of Lynn Conway and her multiproject chip efforts, which helped to drive the VLSI electronics revolution). At the time we started this project, the only users of PDMS microfluidic chips were laboratories who were also expert in the manufacture of the chips themselves.

With the support of this supplement, we successfully designed a micro-cell sorting device that can be incorporated into a microfluidic chemostat, previously designed by the Quake lab at Caltech (now at Stanford). The new system, which we named the "sortostat", is capable of applying continuous and programmable selective pressures to mixed cultures of microorganisms. For example, a mixed population of bacteria, containing a starting distribution of 50% cells expressing yellow fluorescent protein, and 50% cells expressing cyan fluorescent protein, can be maintained, and then driven to any arbitrary new distribution (e.g., 80:20% yellow:cyan), and back (e.g., 20:80% yellow:cyan) before being returned to an even distribution (e.g., 50:50% yellow:cyan).

To develop and operate the "sortostat" and related microfluidic systems, we purchased the required hardware to assemble computer-controlled actuation of pressure-driven push-up/push-down PDMS valving. We also designed the sortostat chip itself, working with the staff at the Caltech PDMS microfluidic fabrication facility in order to develop and refine rules so that chips that were designed off site (here at MIT) could be successfully manufactured by the facility at Caltech and, most importantly, would work as expected upon delivery.

A manuscript detailing our design of the sortostat system, as well as the needed

equipment, and lessons learned in working as a first off-site user of a PDMS fabrication facility will be documented in a manuscript that we are submitting for publication in 2008. In supporting this work, the supplement also provided indirect support (e.g., materials and equipment needed to construct PDMS microfluidic devices and accompanying control systems) for two MIT PhD students, Jason Kelly and Ty Thomson, both of whom are expected to graduate in June of 2008.